Helwan University
Faculty of Engineering – Mataria
Mechanical Power Engineering Department

A Course on

Conservation

Control Fundamentals

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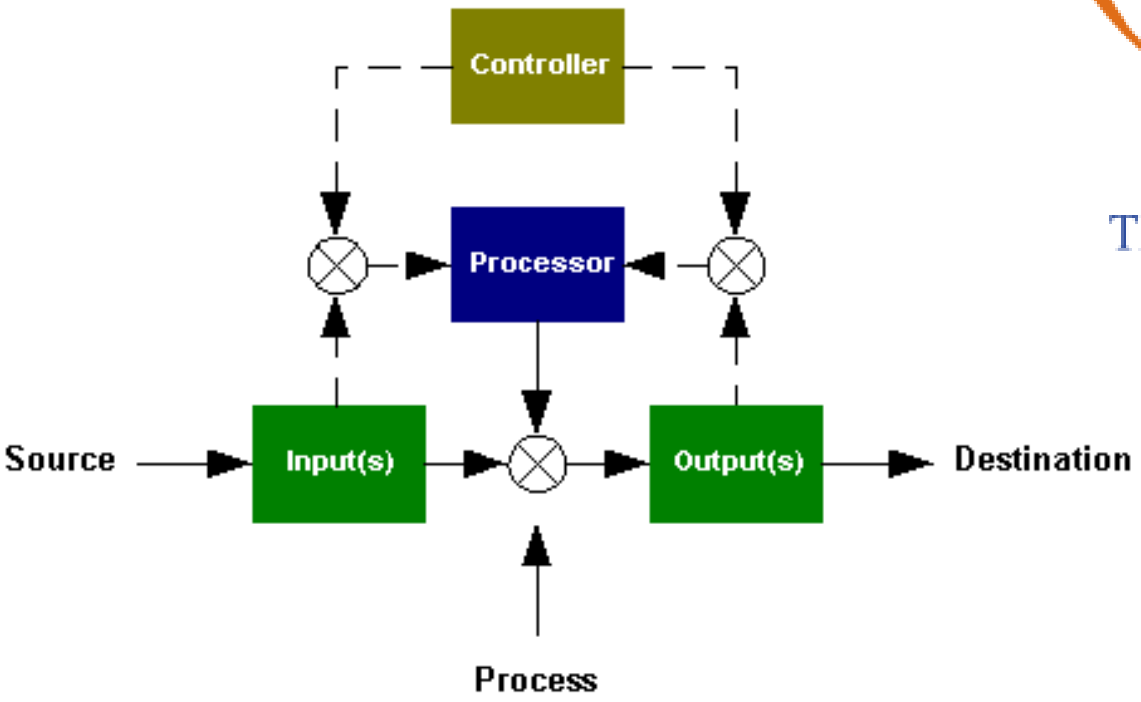
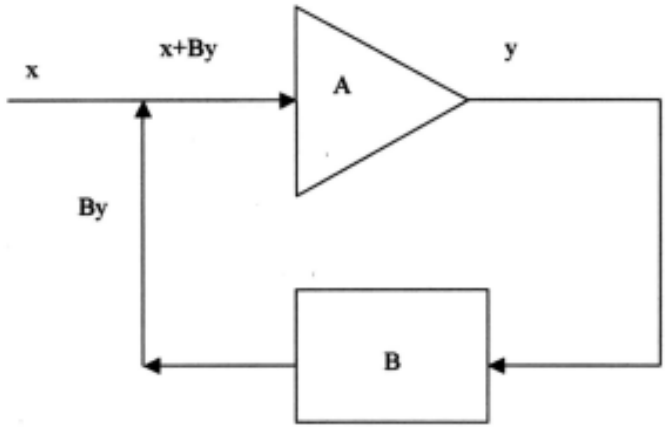
2012

INTRODUCTION

A control system should be used to provide adequate feedback of the many complex processes in the building.





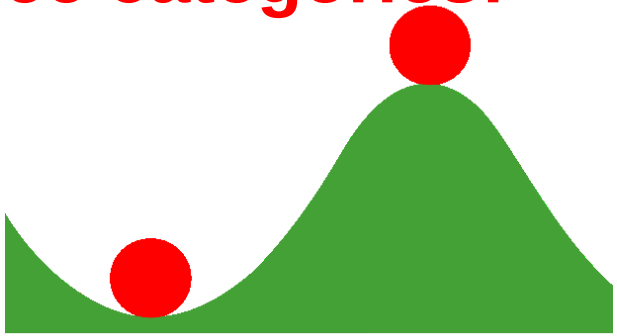
INTRODUCTION

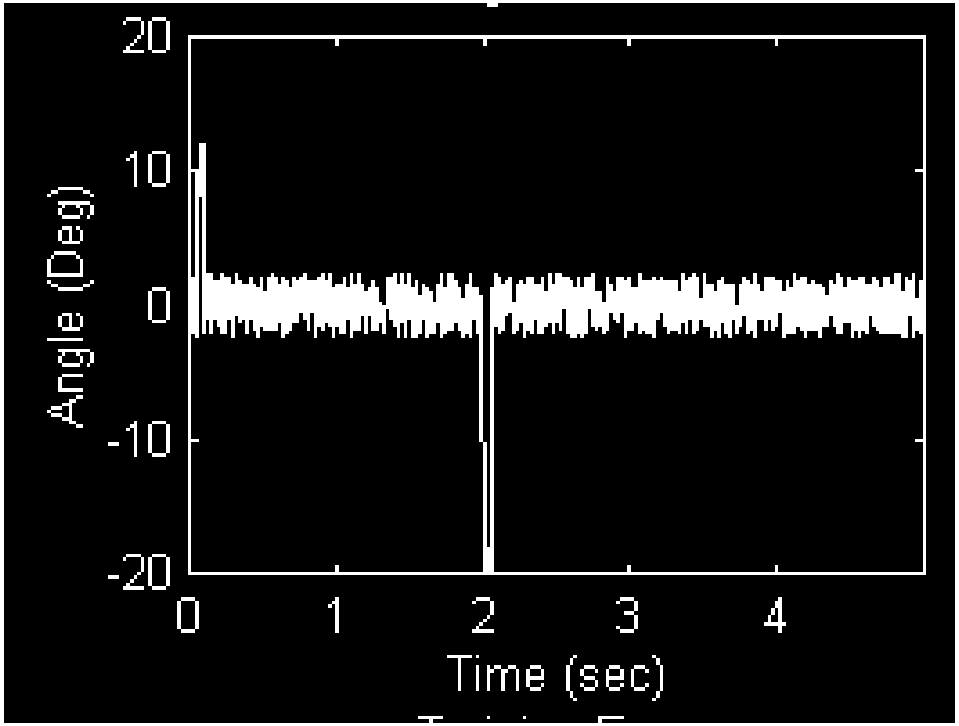
The main objective of the control system is process stabilization.

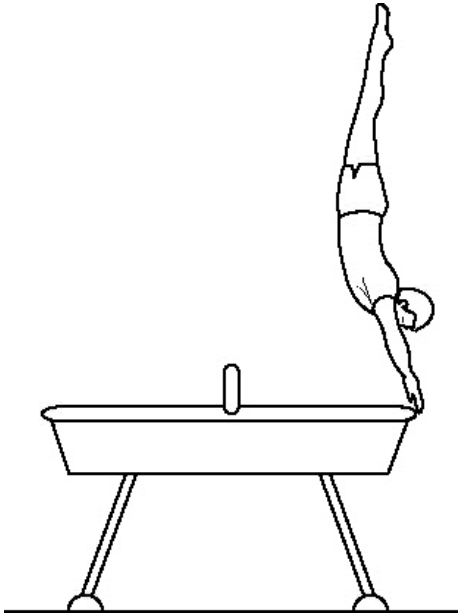
Introduction

***Stabilization is* divided into three categories:**

- ***Self-stabilizing***
- ***Moderate self-stabilizing***
- ***Unstable***

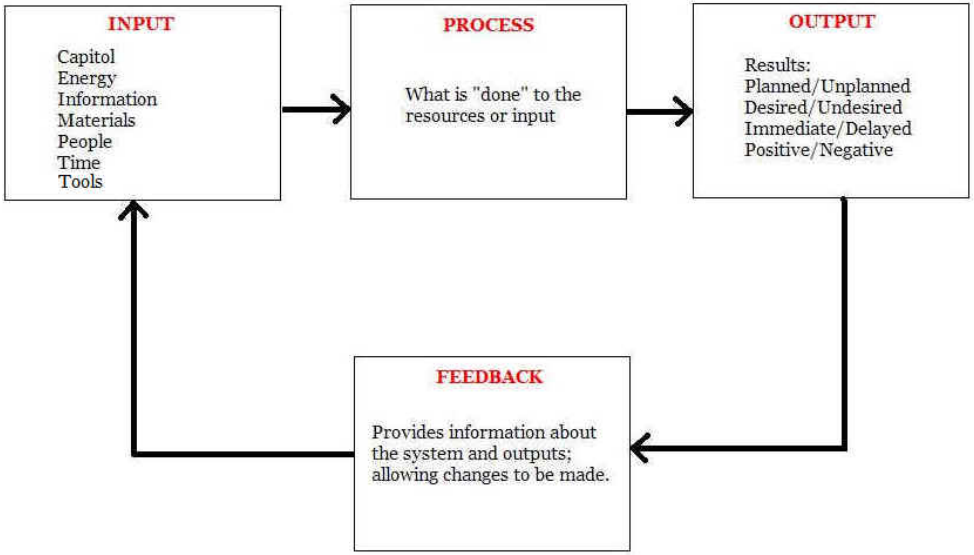






Overview of Control Systems

Process: The output of the process is called the process value.

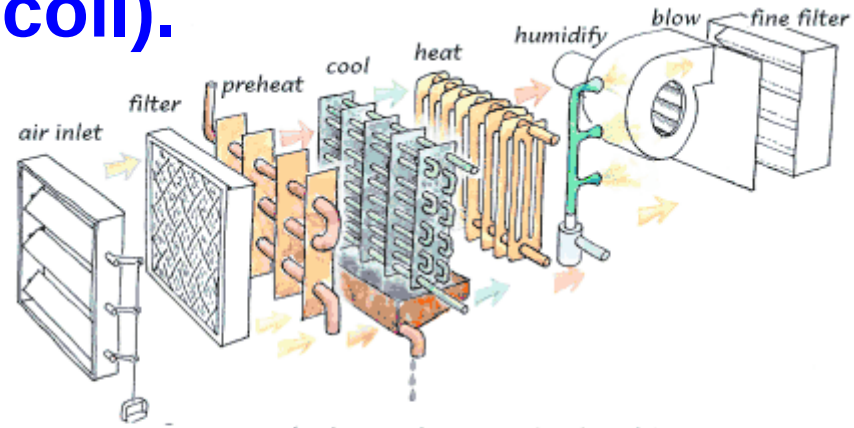


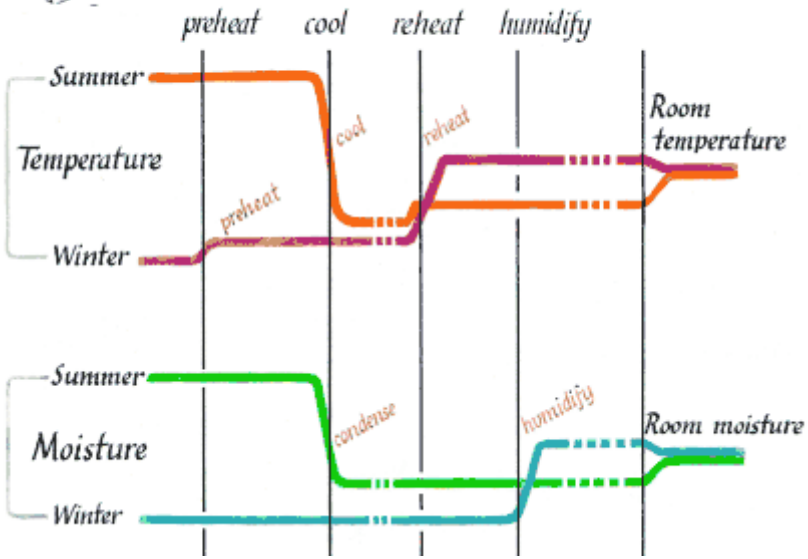
Overview of Control Systems

If a positive action causes an increase in the process value, then the process is called *direct-acting* (heating coil).

Overview of Control Systems

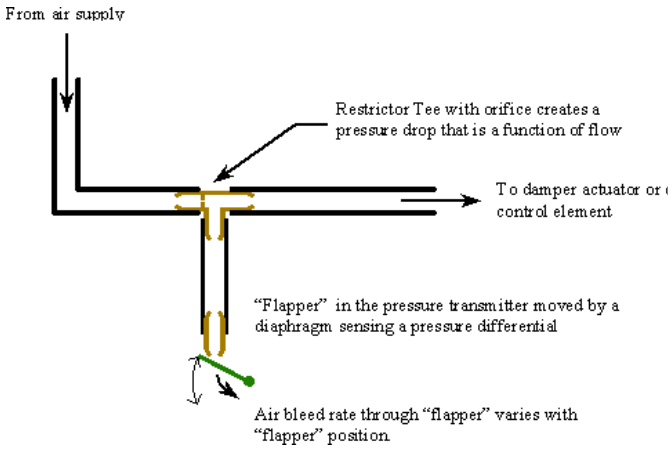
If positive action causes a decreases in the process value, then the process is called *reverse-acting* (cooling coil).





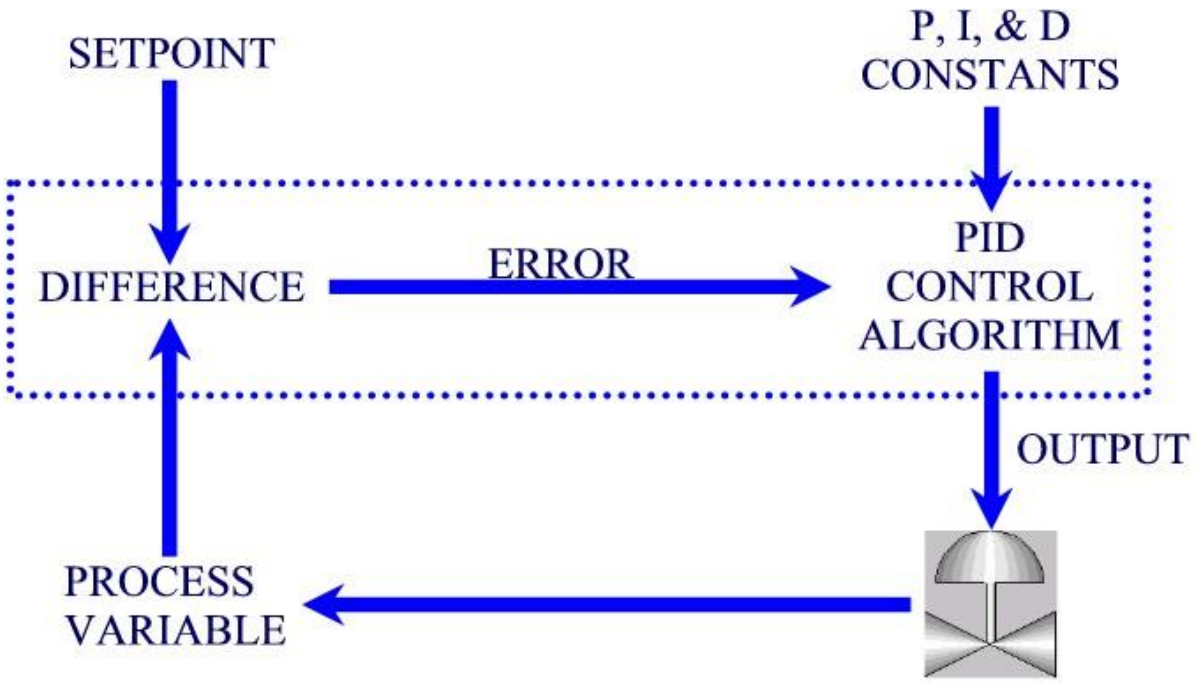
Overview of Control Systems

Sensor: a device that produces some kind of signal indicative of the process value. Sensors use pneumatic, fluidic, or electric impulses to transmit information.



Overview of Control Systems

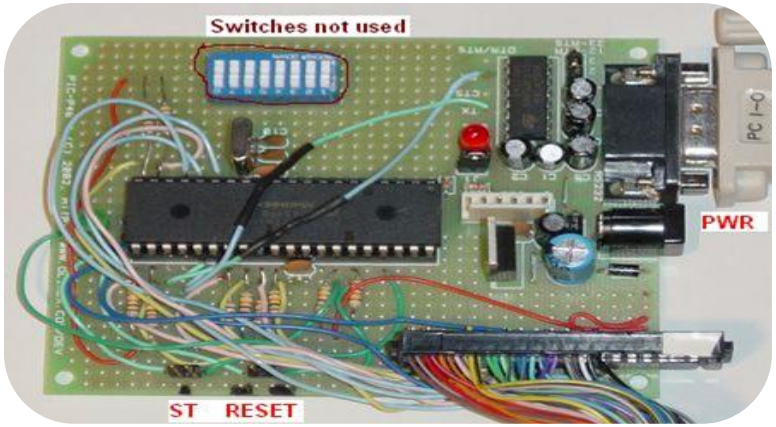
Setpoint: the desired value for a process output. The difference between the setpoint and the process value is called the *process error*.



Overview of Control Systems

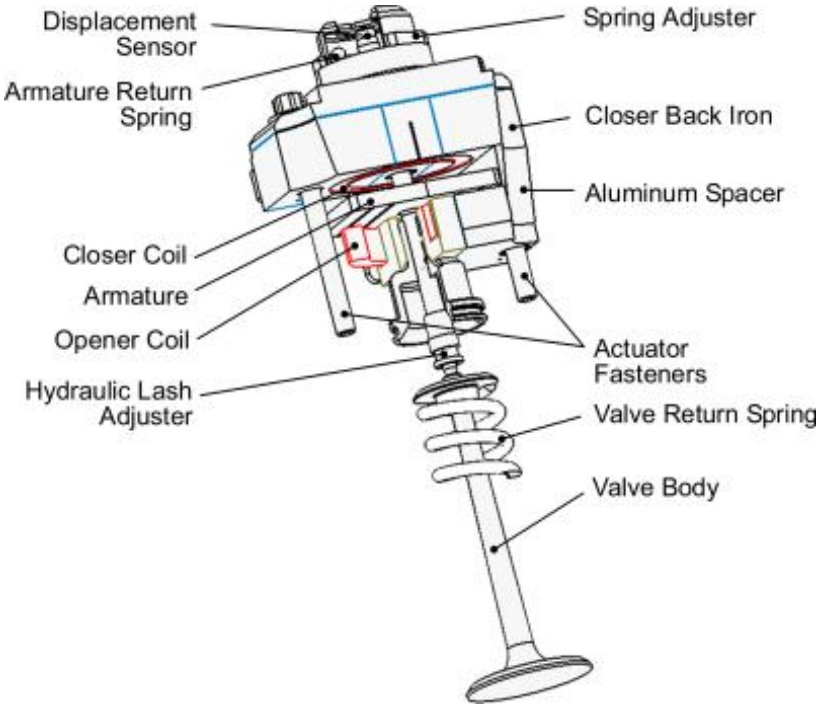
Controller:

- **Sends signals to an actuator to affect changes in a process.**
- **Compares the setpoint and the process value to determine the process error.**
- **Uses this error to adjust the output and bring the process back to the setpoint.**



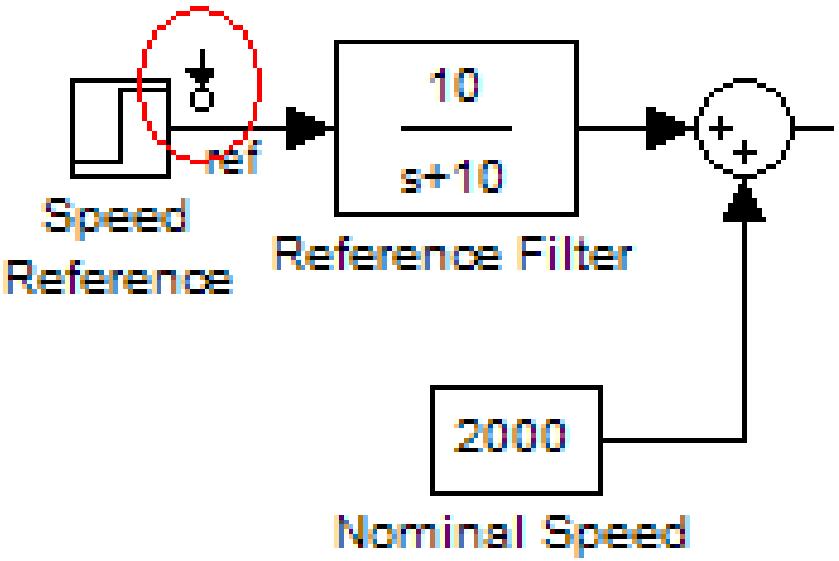
Overview of Control Systems

Actuator: Device that moves a damper or a valve, activates a relay, or performs any physical action that will control a process.



Overview of Control Systems

External disturbance: any driving force that is unmeasured or unaccounted-for by the controller.



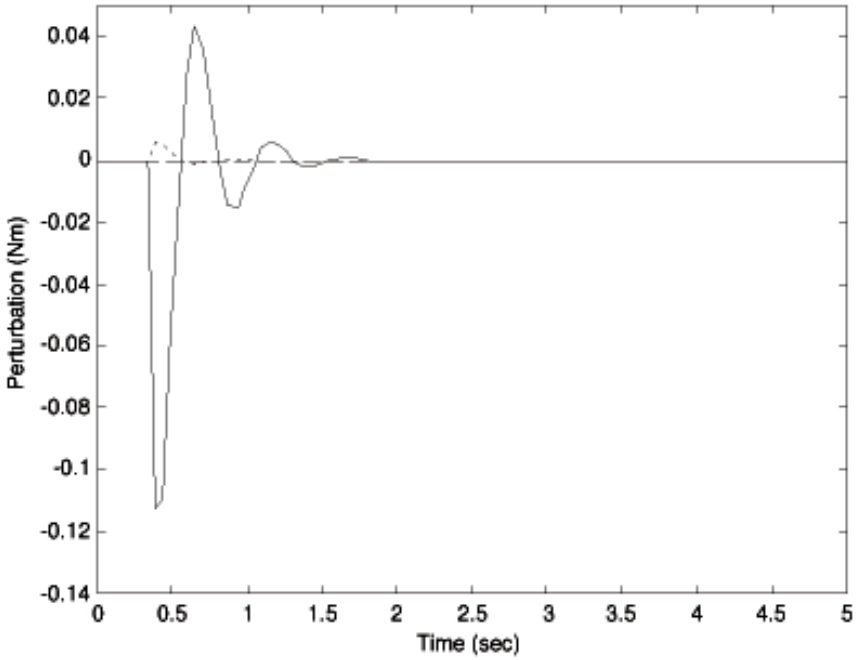
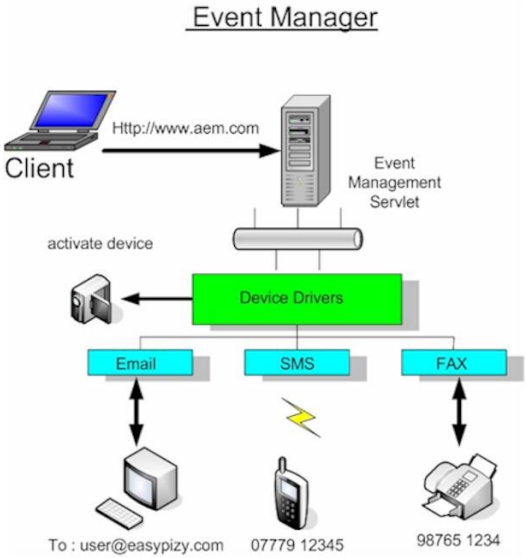


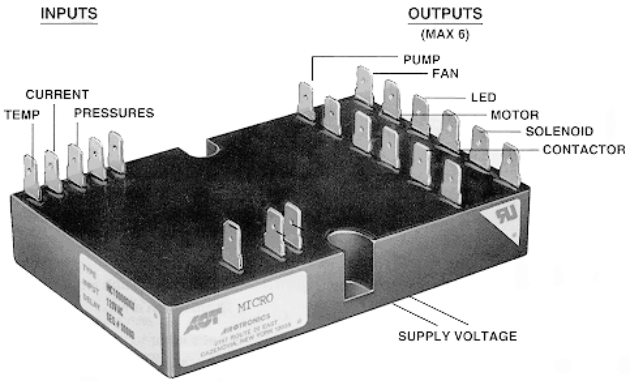
Figure 6: Disturbances in joints 1 and 3.

Overview of Control Systems

Open-loop system: no feedback.

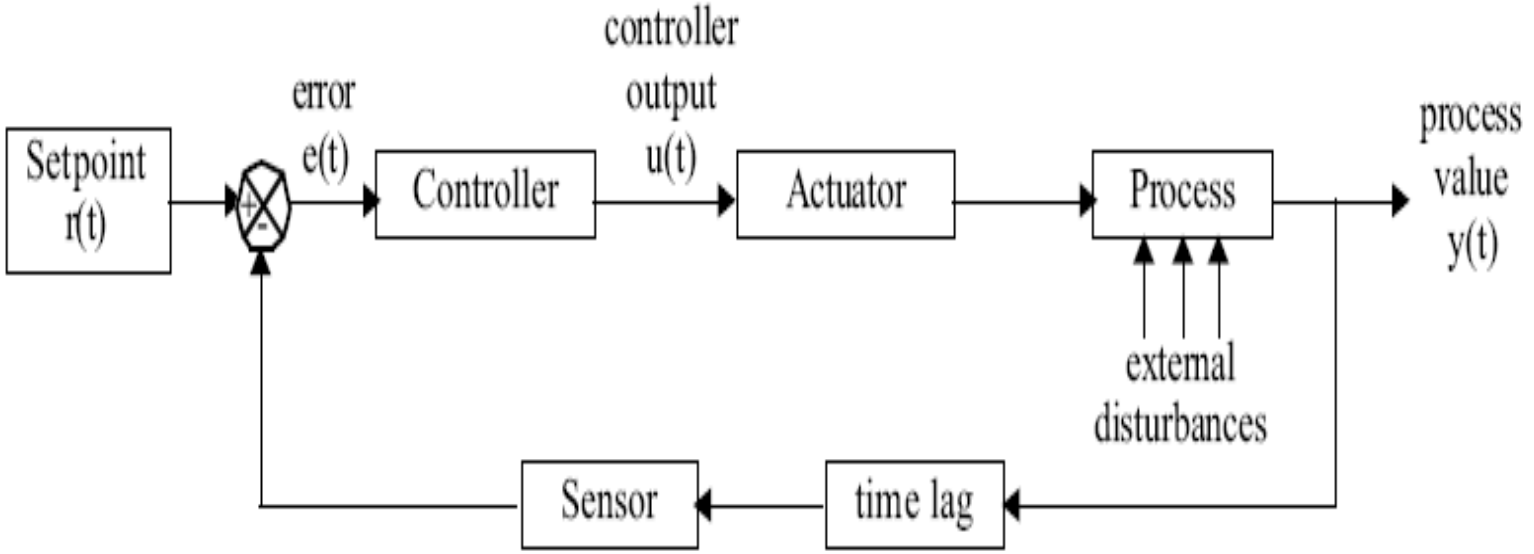
Timed on/off devices are open loops.

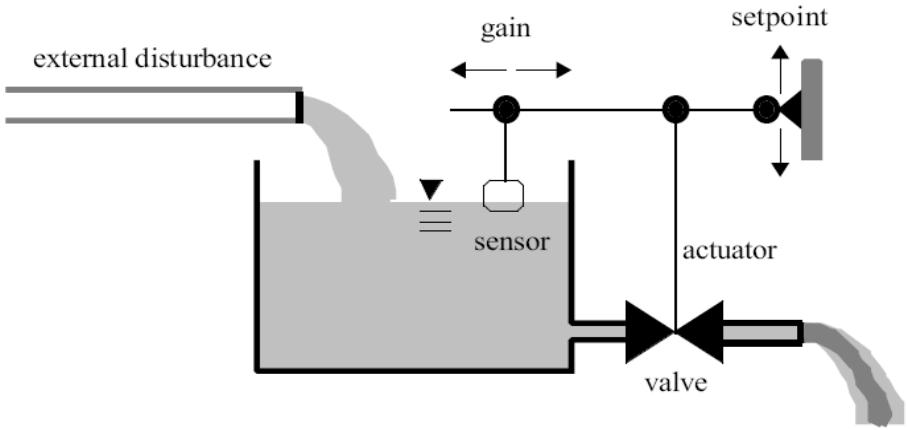




Overview of Control Systems

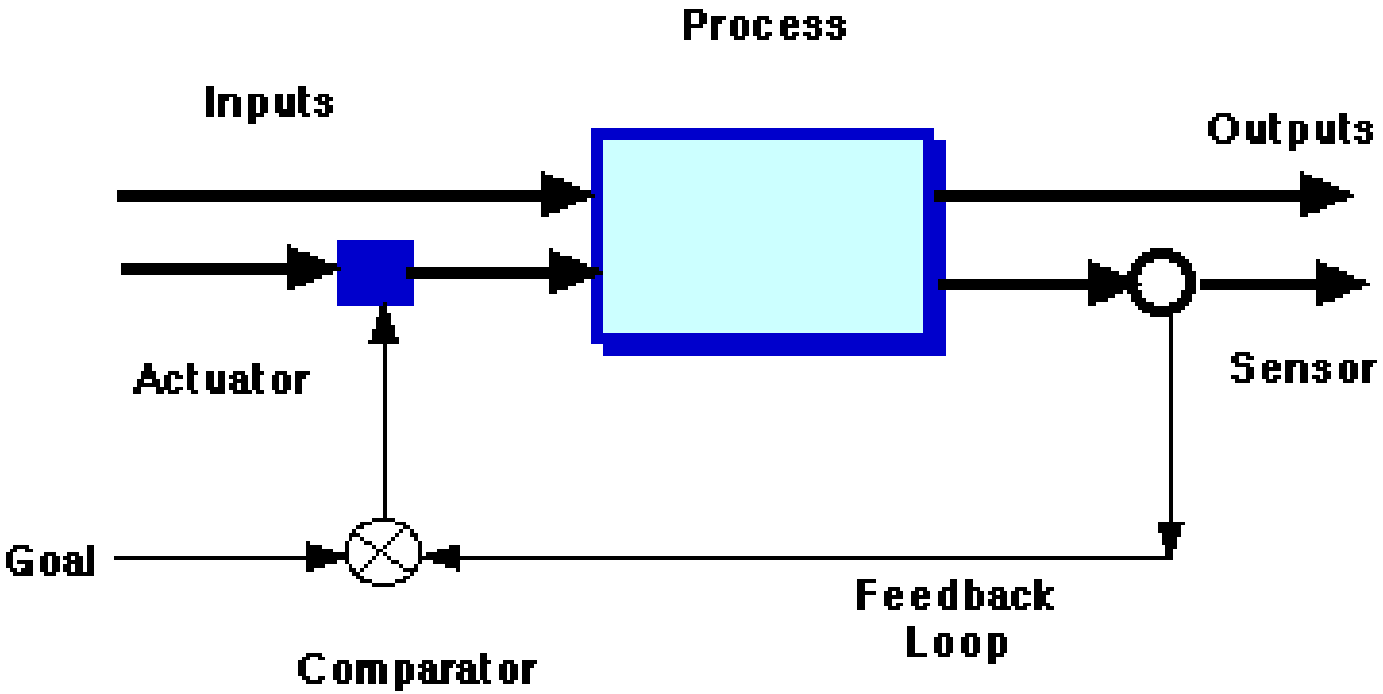
Feedback (closed-loop) system: contains a process, a sensor, and a controller.





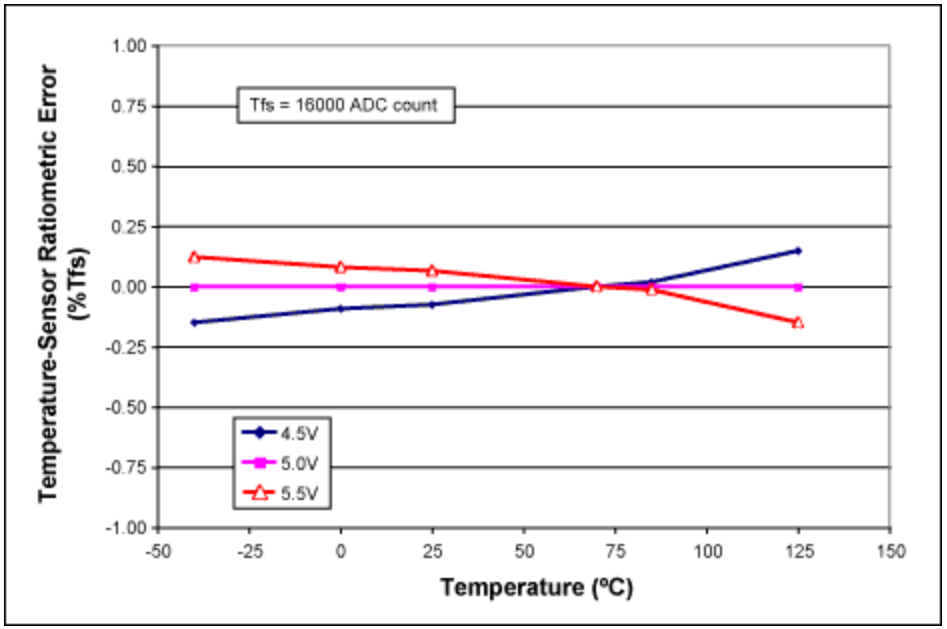
Sensors

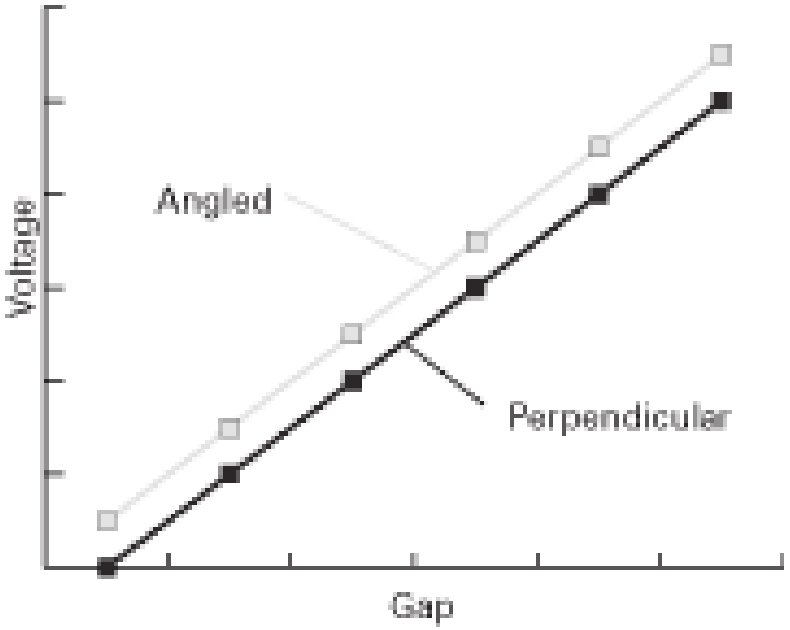
Closed-loop control of building systems is possible only if the control system is able to accurately measure the process.



Sensors

Actual value: This value can never be known with absolute certainty since it must be determined by measurements that will always incorporate some error.

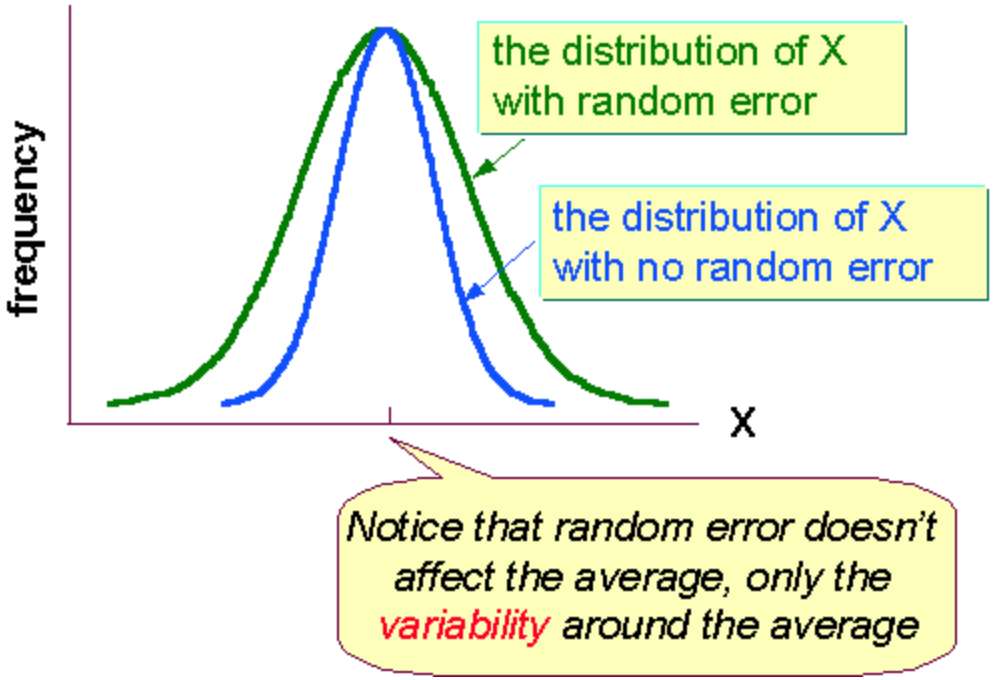




Sensors

Measured value (or process value):

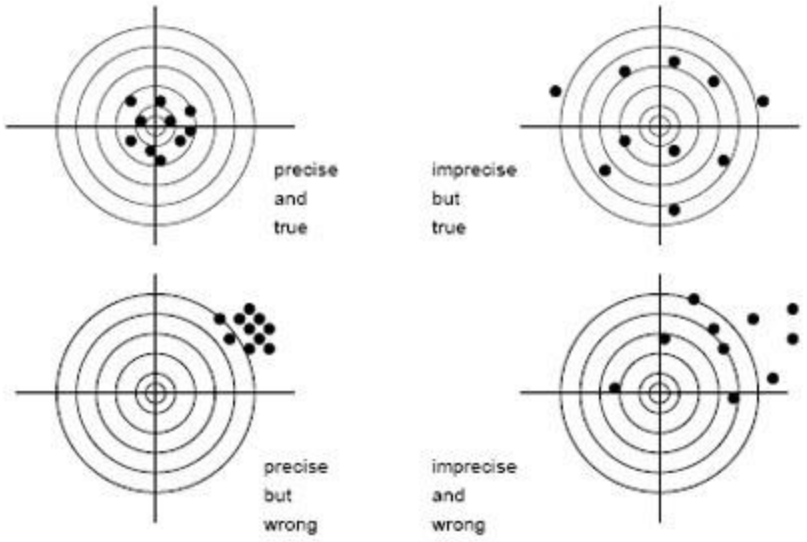
The measurement error is the difference between the actual and measured values.



Sensors

Uncertainty: Is the probable range of the errors

Process value = Actual value ± Uncertainty



Sensors

Process range: will vary between some lower and upper bounds relating to the dynamics of the physical process.

Example:

Zone temperature should be 15 to 18 °C

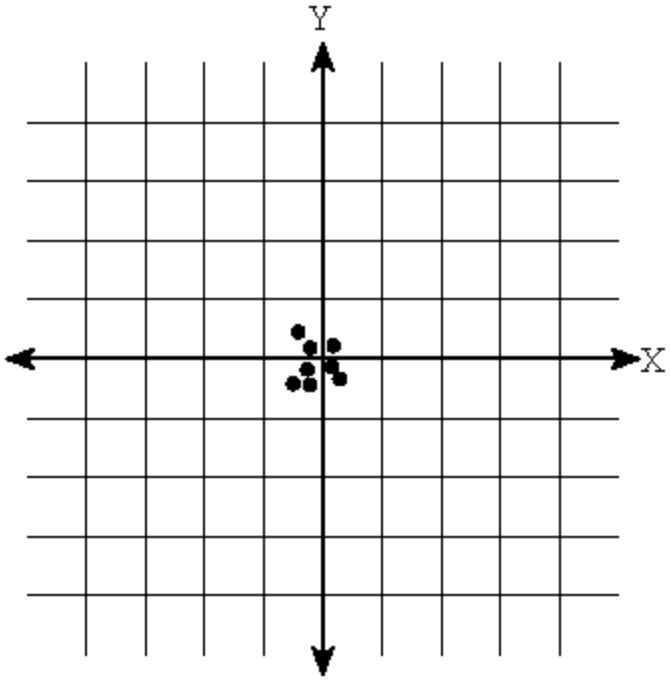
Sensors

Accuracy of a sensor: usually specified by the manufacturer of the instrument.

This can be given in engineering units:
(e.g., ± 1°C) or
(e.g., ± 5% full scale)

Sensors

Repeatability: the ability of a sensor to measure the same value during successive measurements.



High Accuracy
High Repeatability

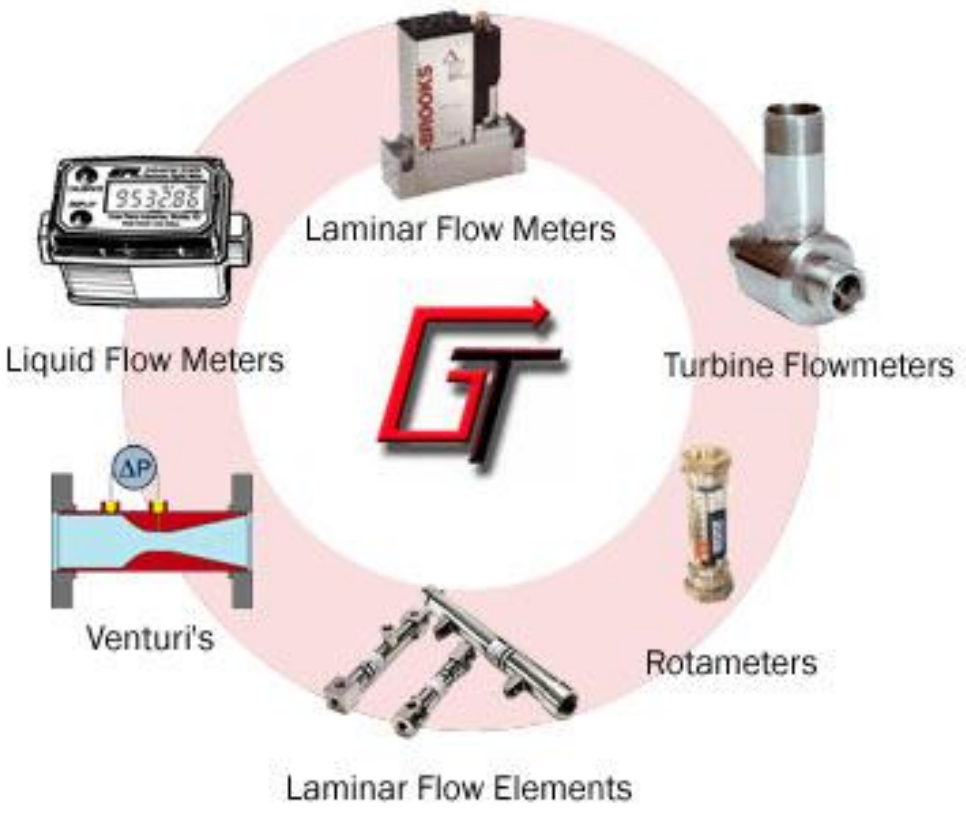
Fig. 4c

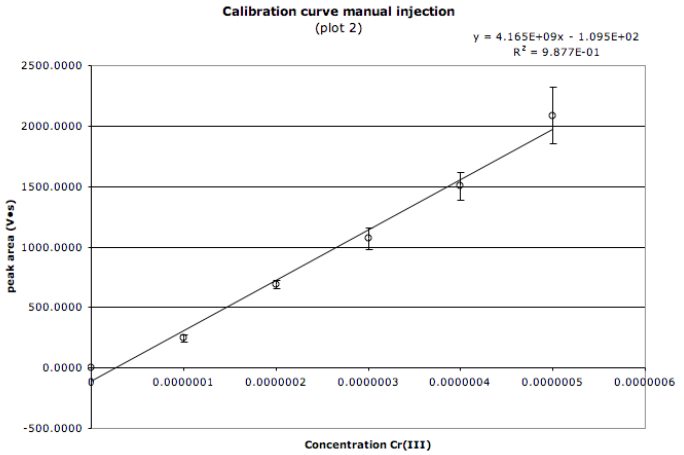
Sensors

Sensitivity: the ratio of the change in the sensor output corresponding to a unit change in the measured variable.

Sensors

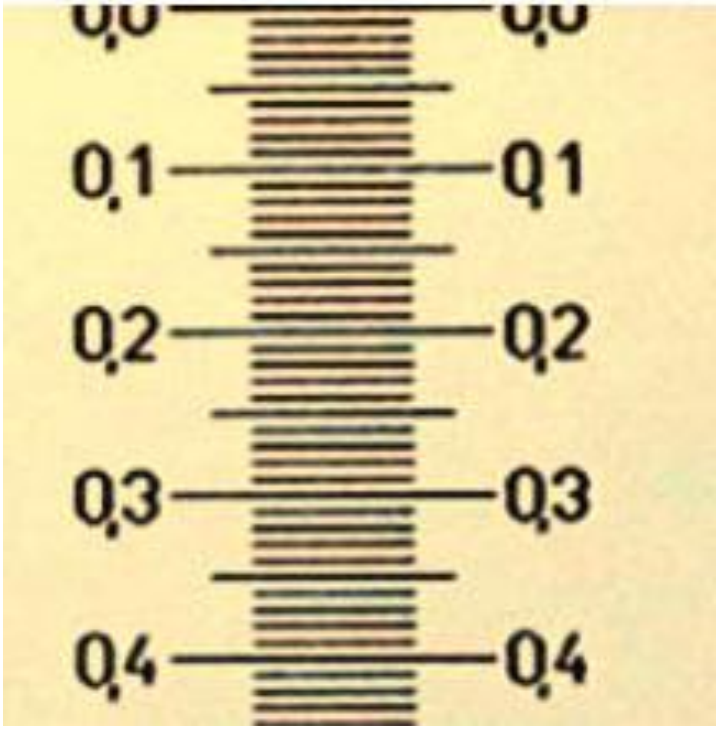
Calibration: the relationship between the sensor output and the corresponding engineering units.





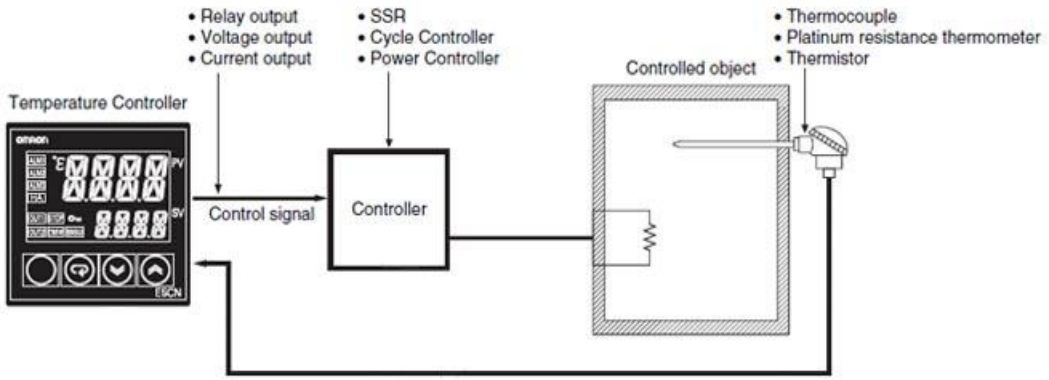
Sensors

Resolution (of a sensor): the smallest readable change of the value of the measured variable.



Electronic Temperature Sensors

Almost all electronic temperature sensors use thermocouples, thermistors, or RTDs. The output of these sensors is often amplified or otherwise modified to provide a more meaningful signal to the control system.

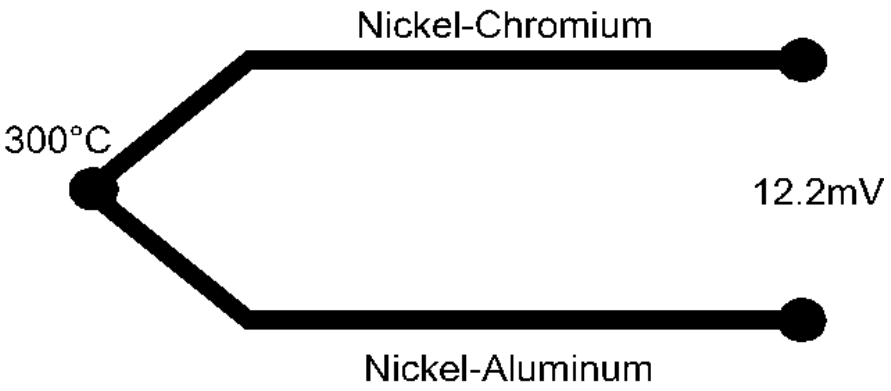


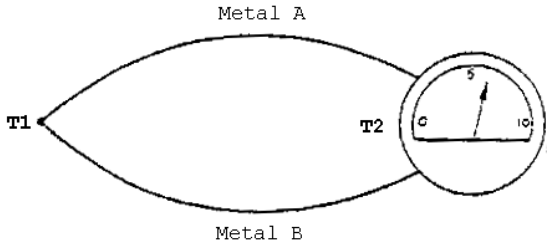
Electronic Temperature Sensors

Thermocouple

Two dissimilar metals are in contact.

A current is generated that corresponds to the temperature of the junction.





Electronic Temperature Sensors

Advantages of thermocouples include:

- **Self-powered** — no excitation voltage is necessary
- **Simple**
- **Rigged**
- **Inexpensive**
- **Wide variety**

Electronic Temperature Sensors

Disadvantages of thermocouples include:

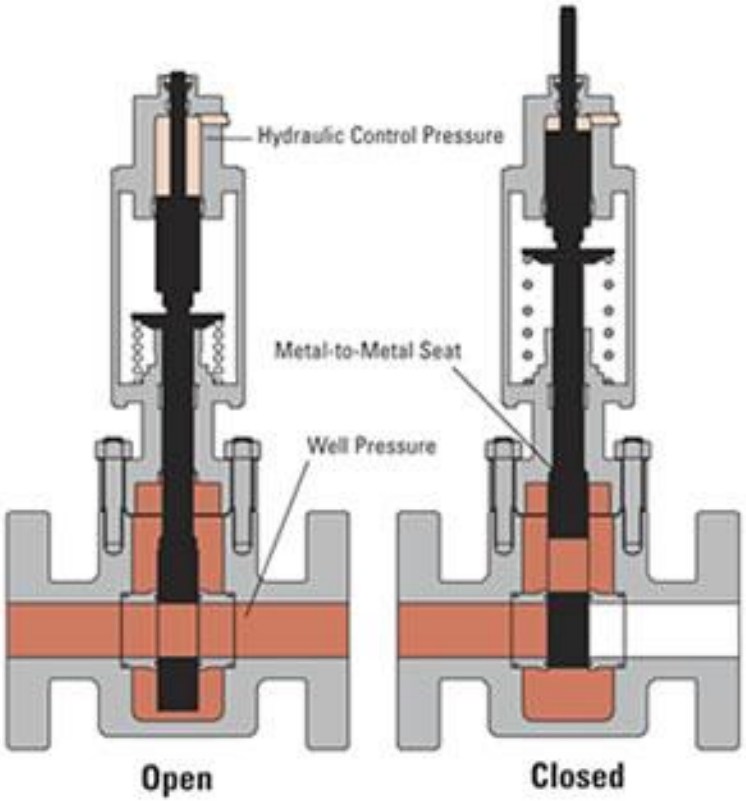
- **Non-linear —conversion**
- **Low voltage — needs amplification**
- **Reference required**
- **Accuracy may be ± several degrees**

Actuators

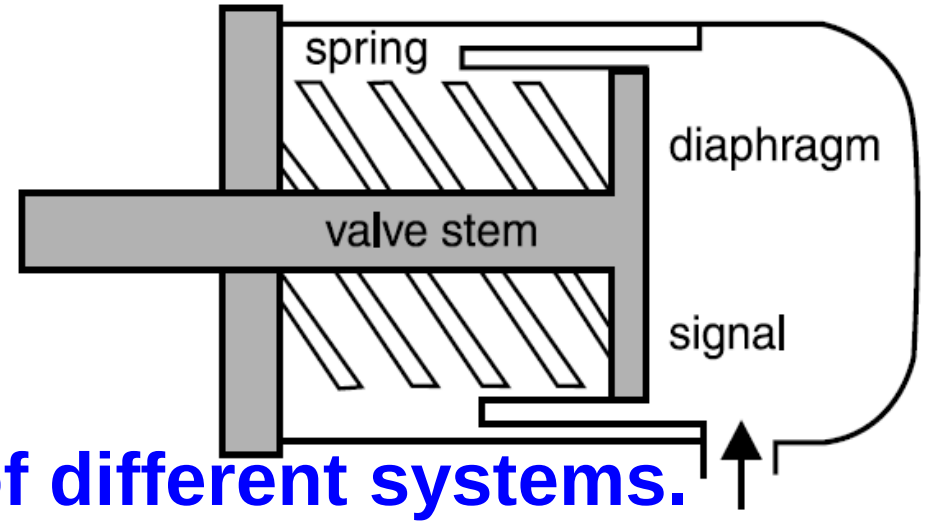
Electric and Electronic Actuators

Use a series of motors and reduction gears to move valves and dampers.

Translate a signal into an actuator position.



Actuators



Pneumatic Actuator

- **Is an important part of different systems.**
- **Uses compressed air to generate force on the diaphragm.**
- **It is possible to generate sufficient forces to move valves, dampers, etc.**
- **Is generally much faster than electronic actuators.**
- **Is often more bulky than electronic actuators.**
- **Typical air pressures used in such systems vary from 3 to 20 psi.**

The Control Loop

A control loop must have at least the following:

1- An actuator that affects the process
2- The process being controlled
3- A sensor to measure the process value
4- A controller that calculates the error and sends a signal to the actuator
5- A setpoint input

The Control Loop

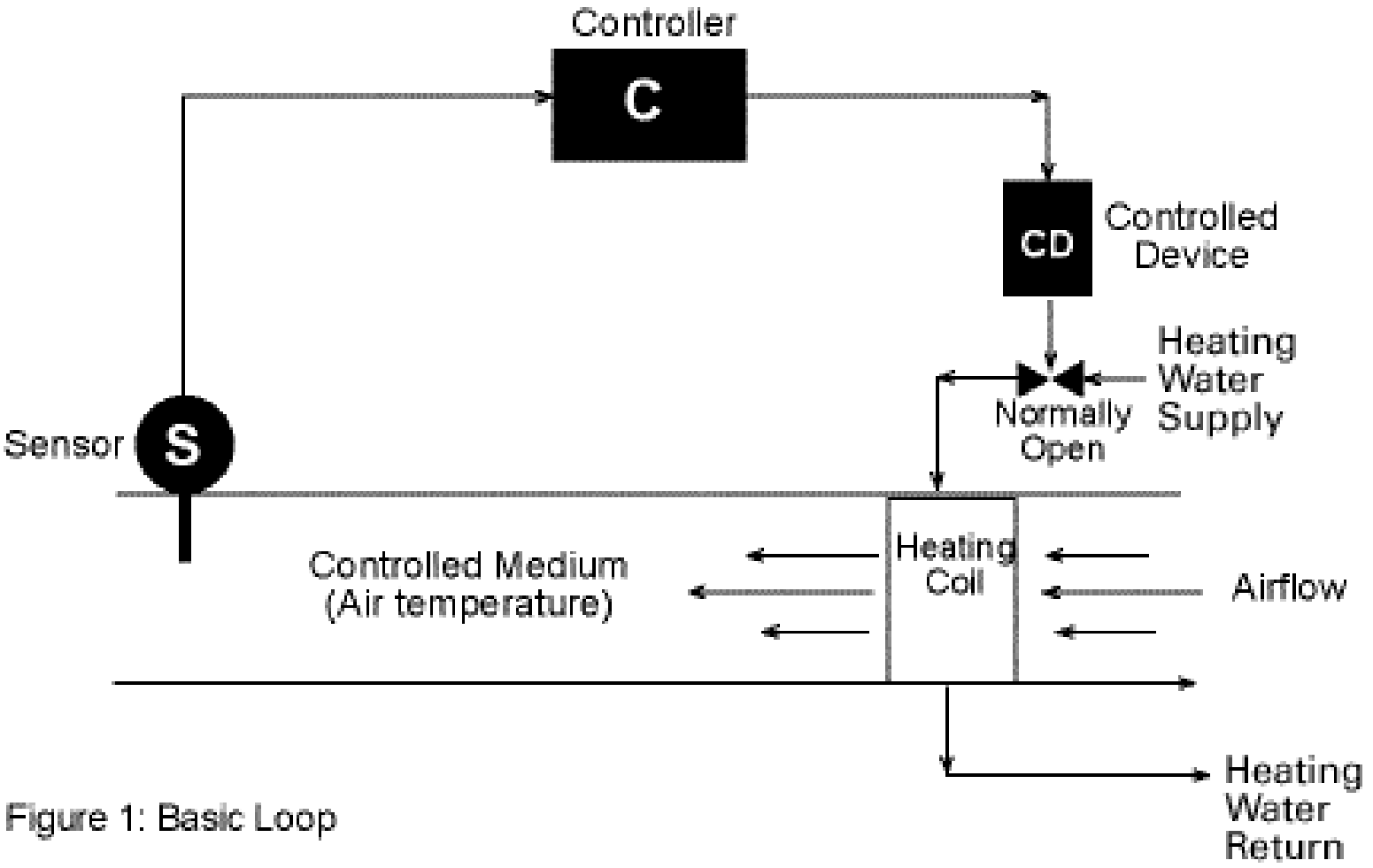
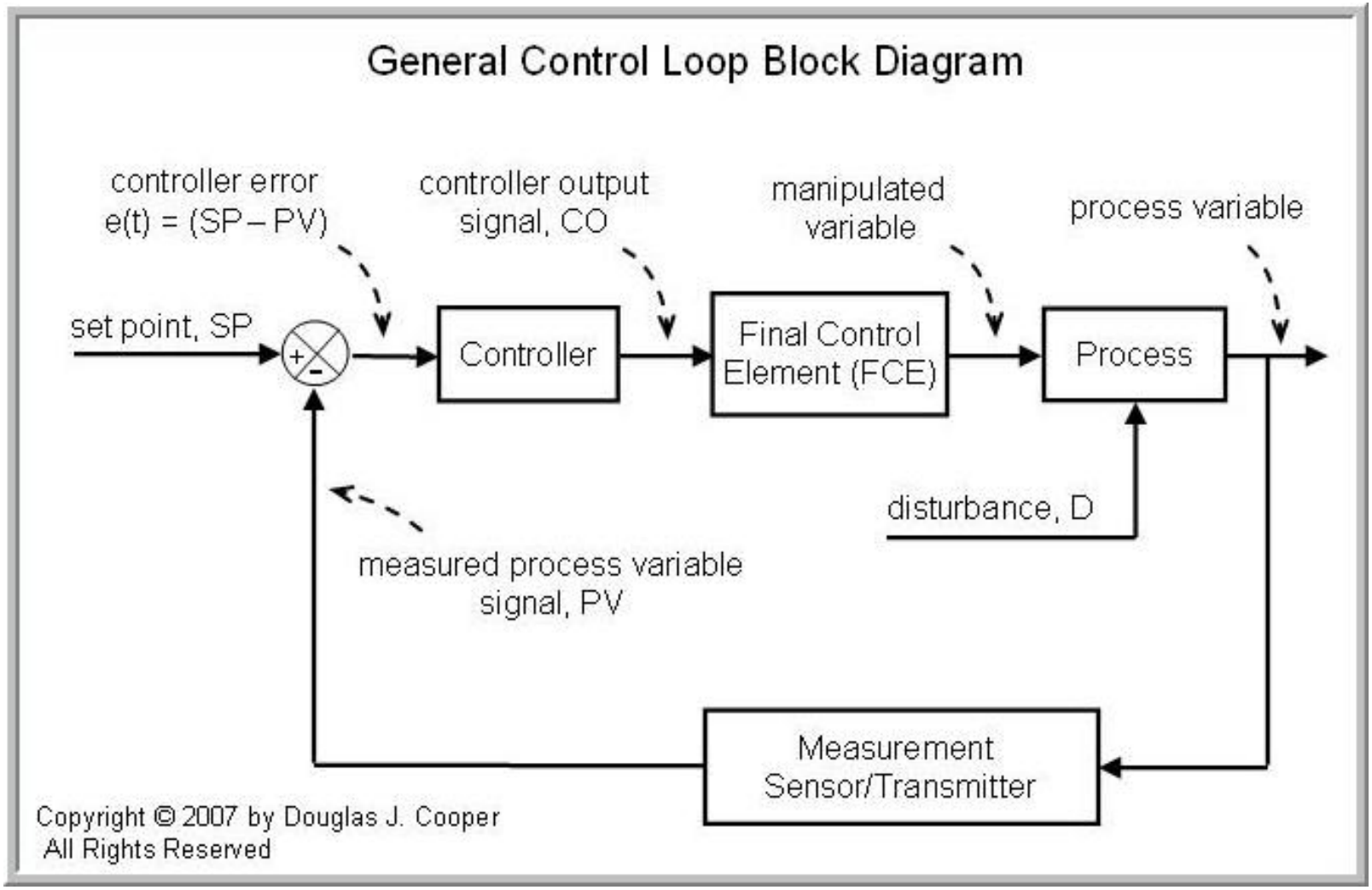
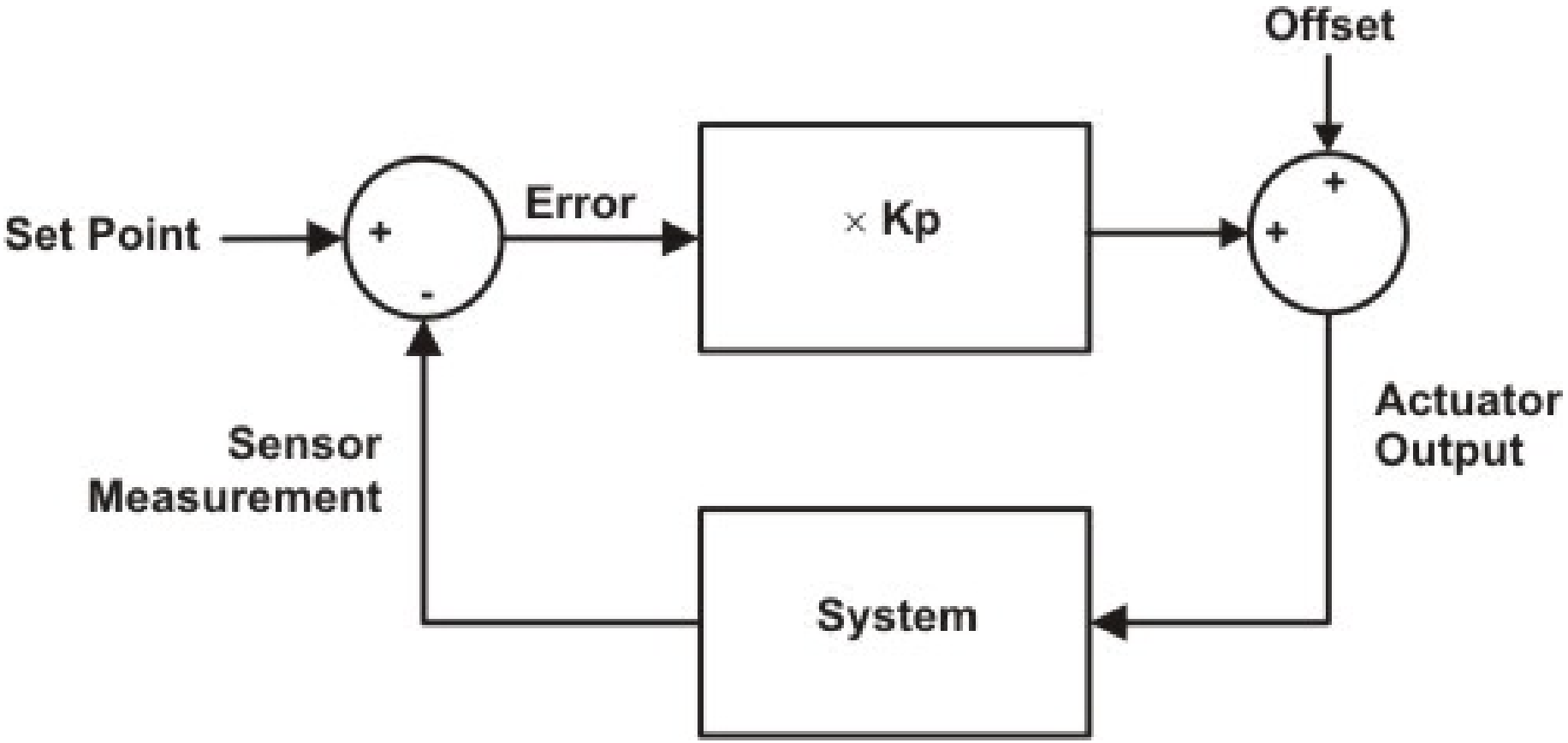


Figure 1: Basic Loop

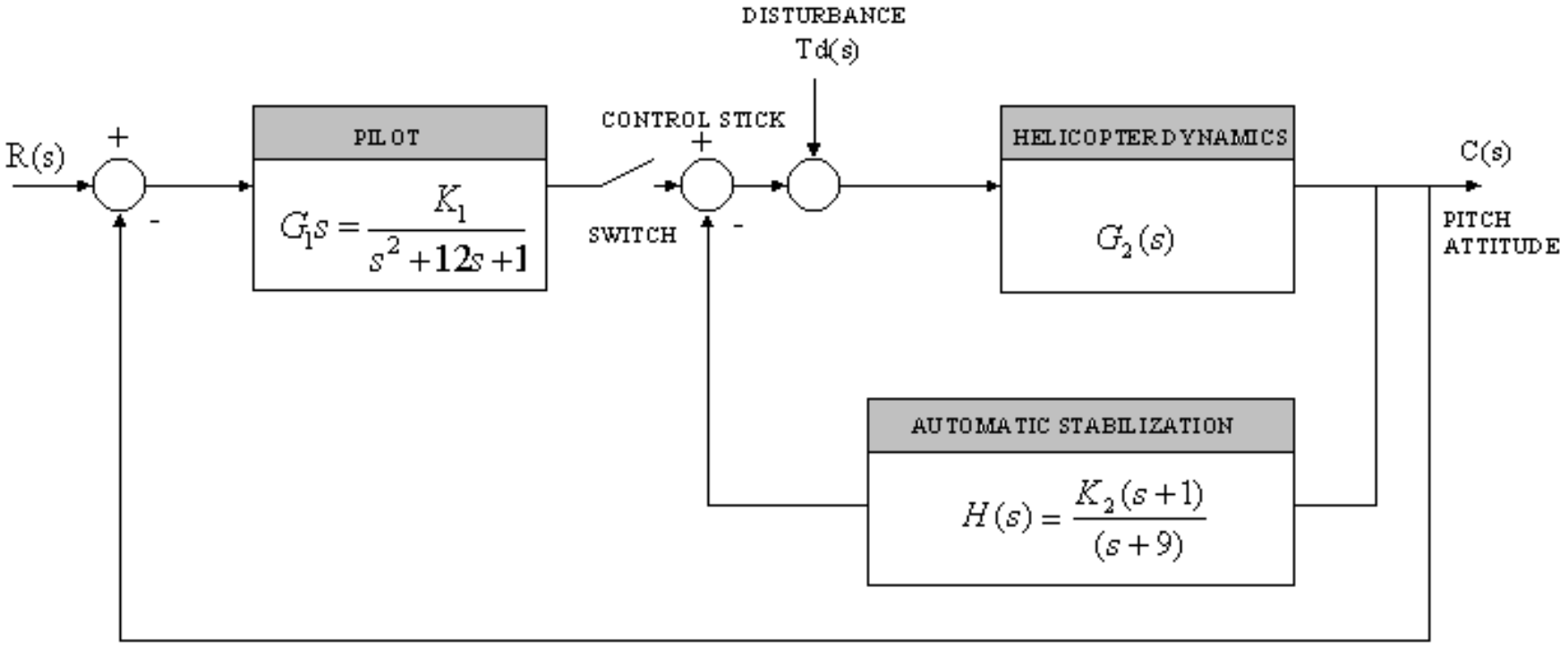
The Control Loop



The Control Loop

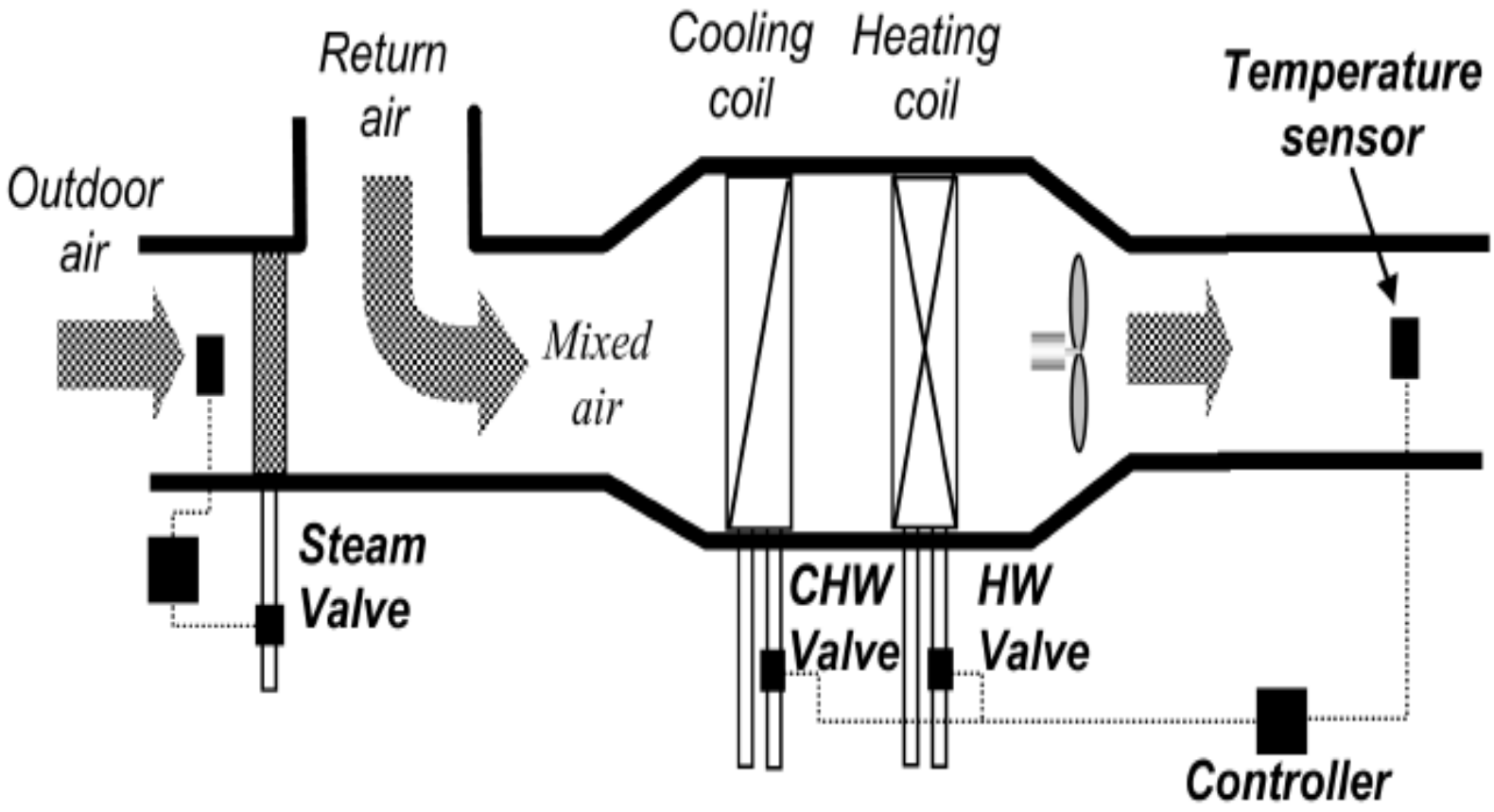


The Control Loop



Control of Air Distribution Systems

Recall



Control of Chillers

There are a number of safety controls:

1- A distribution loop system which guarantees flow through the evaporator barrel and insures against freezing.

2- High condenser pressure

3- Low refrigerant pressure or temperature

4- High motor temperature

5- Motor current overload

6- Low oil temperature

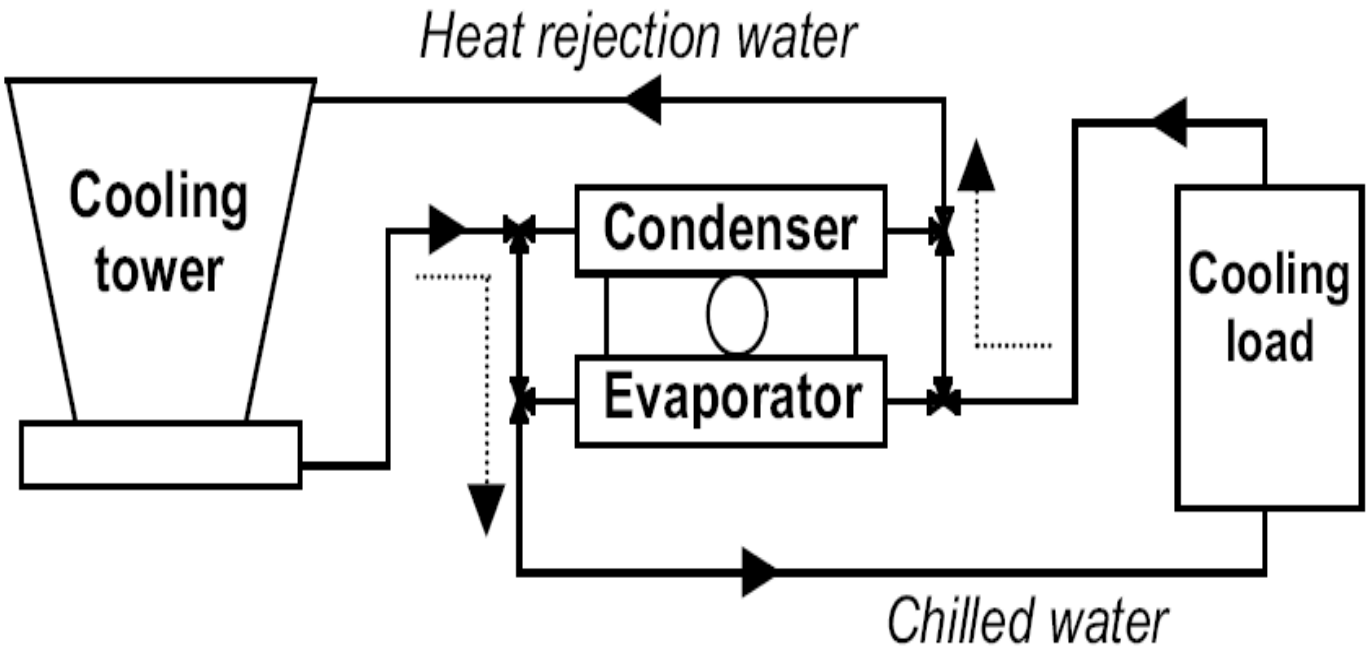
7- High oil temperature

8- Evaporator water flow interlock

9- Condenser water flow interlock

Cooling Tower Control

Cooling towers are typically controlled to maintain the condenser return water temperature. This is done by either staging multiple cooling tower fans or by varying the fan speeds with variable frequency drives.



Control of Boilers and Steam Systems

- **Steam is a convenient "prime mover" since it does not require an additional pumping power to circulate.**
- **The boiler produces steam, and the steam expands into the distribution system.**
- **There will be some condensation as some of the steam cools (steam traps and condensate receiver tank).**
- **A float switch in this tank closes when the tank is full and activates a pump that returns the condensate back to the boiler.**

Control of Boilers and Steam Systems

1- Boilers have safety controls that will shut off the boiler (or prevent ignition) if a condition exists that is hazardous to the equipment or the facilities personnel.
2- Some boiler combustion safeties include shutting off the gas flow.
3- There is a water flow interlock to prevent boiler operation when there is no water flow.
4- Large boilers monitor flue gas conditions to estimate combustion efficiency.
5- O_2 concentrations should be around 3 to 5 %.

Control of Boilers and Steam Systems

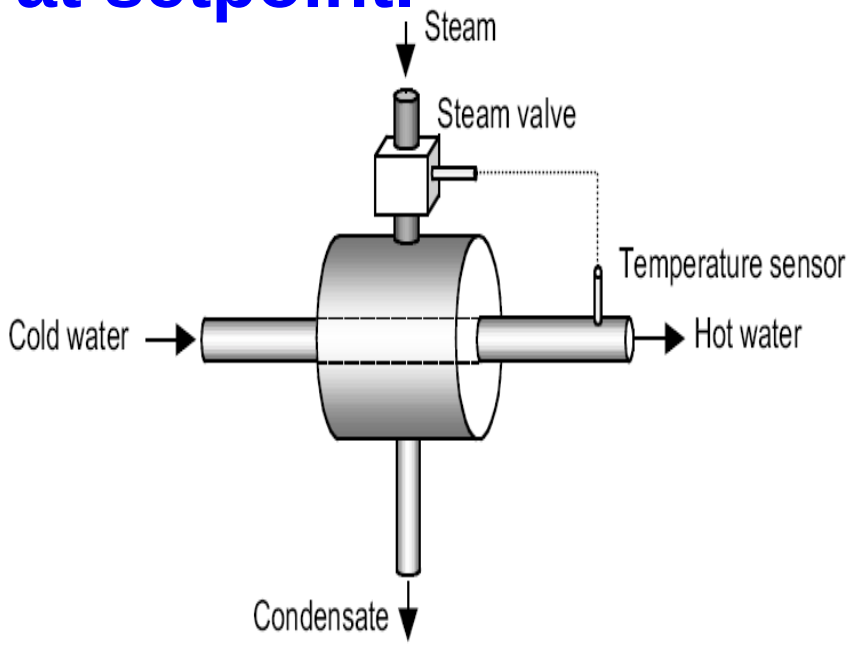
Steam/Hot Water Converter

1- Is like a heating coil, except that it is much smaller and heats water, not air.

2- The water and steam never mix.

3- Are used instead of multiple water heaters.

4- The steam flow is controlled to maintain the hot water temperature at setpoint.



Thank you

Any questions

effluents	تدفق
recuperator	معوض
cure	معالجة